TIPS FOR SOLVITA® FIELD SOIL TESTING
How to Obtain the Best Results

Soil Factors: Measuring soil respiration in the fresh field samples with minimal disturbance is dependent on variables which are spatially limited and dependent on temperature and moisture. When using the field test to make comparisons between fields and farms it is advisable to sample under similar conditions. If comparing from year-to-year it is also advisable to sample when environmental conditions are known to be comparable.

Use of the DCR Field Unit: The Digital Color Reader (DCR) is a sophisticated mini-spectrometer that is pre-calibrated to Solvita conditions. The principle is to convert color results to CO_2 concentration and report either as mg/kg or mg/liter or kg/ha as CO_2-C. To convert to lbs CO_2 multiply by 3.7. Firmware updates are noted at *solvita.com/digital-color-reader/*

User-Calibration: Solvita results are calibrated for the standard volume of soil + air or headspace in a Solvita® jar or as shown in Section 4 on page 3. These relationships have been updated in Nov 2018 and 2020 to obtain the best results. If users wish to calibrate to other conditions, the Solvita color number (optical density unit) should be used as the dependent variable.

Metric vs Imperial (English) units: To change the Green Field DCR between reporting units hold down the READ button for at least 10 seconds, release the button, then turn device off and repower.

DCR Software: Solvita Reader software is used to record the DCR readings directly into a .csv file when attached by USB cable to a PC. The software is included in new purchases of a DCR. The DCRs possess internal data storage capability, allowing uploading of all results from the unit at a later point.

On-Line Calculator for Solvita Field Test results: An on-line calculator that estimates annual soil functioning based on test parameters may be found at *https://www.Solvita.com/soil/basal-co2-guide/*

Lab Version of Solvita Test: A lab Solvita test called CO_2-Burst is available for testing soil that has bee pre-dried and processed in a manner typical of soil labs. Performing this test requires the yellow multi-mode DCR.

Pouch Longevity: The Solvita probes are specially packaged and sealed to assure freshness for an extended period. The box of probes should be removed from the field case and stored in a cool location when not in use. The probes should not be allowed to freeze.

Technical Support: Woods End Laboratories is committed to see the Solvita test used properly to obtain meaningful and valuable soil results. To this end we are happy to take inquiries by email (solvita@woodsend.com) and will respond as soon as possible.

Solvita.com is *a division of Woods End Laboratories, Inc.*
PO Box 297, Mt Vernon ME 04352 USA, tel: 1-207-293-2457
E-mail: solvita@woodsend.com — www.solvita.com

To register Solvita Equipment go to: https://solvita.com/registration/

SOLVITA®

SOP Version: 2021:3.0
DCR Model 12.4

INSTRUCTIONS
Natural Soil Respiration
Users Guide for Soil Master and Field CO_2 Test

The release of carbon dioxide (CO_2) from fresh soil due to biological activity is a natural phenomena that occurs over a very wide range of temperature and moisture conditions. The *Solvita Field Test* and *Soil Master* are protocols designed for testing fresh, undisturbed soils. The *Soil Master* Kit includes supplies for sampling and preparing soil to obtain proper results.

This application of field respiration testing is meant to reveal soil biological activity under natural, minimally-disturbed conditions. This form of respiration is often called "basal". It differs significantly from laboratory methods that include drying, grinding, sieving and remoistening. Soil testing using the Field Kit and Soil Master approach is intended to reveal "steady-state" conditions, considered normal, background status associated with ordinary soil functioning. The results may be described as "field respiration" or "biological activity of fresh soil".

Soil Health and Benefits for Crop Growth: Measuring the quantity of CO_2-output from soil is a means to assess overall biological functioning, a vital expression of *soil quality and health.* No other type of test more accurately and completely expresses soil biological functioning because CO_2 respiration is a shared trait of all soil-dwelling micro and macro organisms performing metabolic respiration of carbon-containing compounds.

Well cared-for soils normally show appreciable rates of respiration under moist, warm conditions. In addition, plant photosynthesis is dependent on available CO_2 and therefore the quantity of carbon dioxide emitted from soils directly impacts plant growth by supplying CO_2 in close vicinity of the plant surfaces. Thus respiration may provide essential crop information.

STANDARDIZING: When using Solvita with freshly sampled field soils the actual field moisture at the time will play a key role in determining rate. Therefore it fluctuates normally. For making comparisons over time it is best to perform under similar moisture conditions and by noting other conditions such topsoil temperature at the time of the sampling. Soil temperature closely corresponds to average daily air temperature. Correction factors for soil temperature to indicate how it may have affected CO2 rates are shown in Table 2.

Tools Mentioned in this Manual: This guide refers to certain recommended tools including a soil knife, field-scale, sieve, brush and DCR. These tools are all included in the Soil Master Kit or are available by contacting Woods End Labs at solvita@woodsend.com

PLANT GROWTH & SOIL CO_2 RESPIRATION

In addition to providing an index of soil activity, CO_2 soil emissions are crucial for plant growth since carbon dioxide is the basic nutrient of plant photosynthesis. In some cases plant growth may be limited by the availability of CO_2 in the immediate vicinity of the plant surfaces during active assimilation periods. Table 3 illustrates the relationship of CO_2 to crop yields on the basis of plant carbon. It then contrasts this with the equivalent volume of air needed to supply CO_2 without soil respiration and the soil respiration to meet these crop photosynthesis needs.

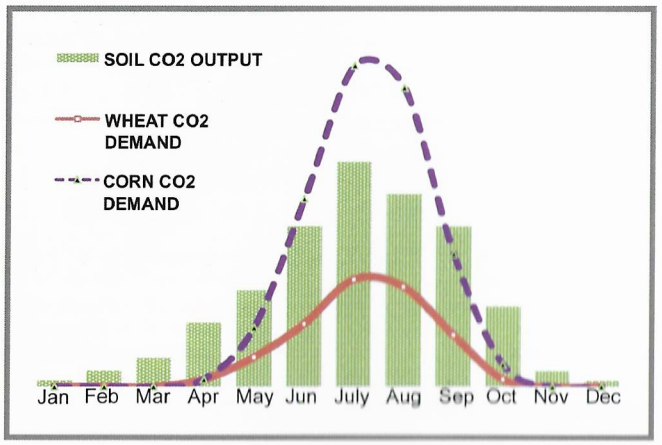
Table 3: CO_2 NEEDED FOR CROP GROWTH

	A	B	C	D*
CROP	Estimated dry yield as ton/a (x 2 = t/ha)	Avg. daily CO_2 Uptake during full season growth lb/a (x 1.12 = kg / ha)	Cubic Quantity of air per a or ha area above crop required to supply needed CO_2	Solvita Soil CO_2-C Respiration Rate which covers C-Need
Wheat	2.5	150	11 cubic	40
Alfalfa	2	130	10	35
Fodder Beets	6.5	440	35	119
Soybean	1.5	90	6.8	24
Corn	5.5	350	27	95

* Column D equals Column B divided by 3.7 converting CO_2 to CO_2-C as used in the Solvita test.

In high functioning ecosystems (such as tropical forests) virtually all the CO_2 and nitrogen released due to soil respiration is utilized and recycled by the canopy. If CO_2 is limiting then nutrients will be inefficiently used. Conversely, if nutrients are limiting, than photosynthesis may be undersaturated, CO_2 supply is inefficient and escapes to the atmosphere. Performing one respiration test does not represent all conditions, and should be repeated to capture the behavior at other times.

Crop CO_2 Demand in Relation to Soil Evolution

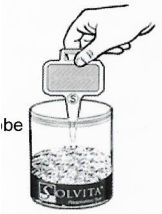


INSTRUCTIONS

mple with
r knife

ample to remove debris
ntly homogenize

l: weigh sample:
265 cc jar or
475 cc jar



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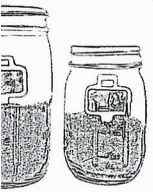

soil increase jar size

MEASURING RESPIRATION
As-is Soil Removed from Field

1. **SAMPLING:** Soil should be freshly sampled prior to the test *under normal, field-moist conditions.* An ideal soil sampler is a soil-knife (pictured) which also indicates depth on the blade. A trowel or spade is also acceptable. Soil-corers are not advisable since they compress and create a shear-surface which may inhibit air diffusion during the test. With a knife or trowel first make a cut to the desired depth, discard the first slice, then cut down the side of the soil trench and place soil onto sieve. Multiple sample points (minimum 12) should be taken across a uniform field if a field representative sample is required.

   SOIL TEMPERATURE: Use any soil thermometer to record actual field soil temperature when sampling. Insert to 3" (7cm) for 6" (15 cm) deep samples. This result can be used to adjust between room temperature and actual field temperature and as a reference in the on-line field calculator (see Table 2).

   SIEVING HOMOGENIZATION: A 6 mm (1/4") sieve or a garden-soil sieve is one of the best means to prep the soil. Handfuls of soil are gently rubbed through the screen. No further processing is required. This step homogenizes soil and helps remove stones and plant debris without damaging the sample. If soil is too wet for testing, it will also be difficult to rub through a sieve.

   SOIL MOISTURE: The Field Kit and Soil Master procedure is intended to show respiration *under natural field conditions* and moisture is not normally adjusted. Ideal sampling is 2-5 days after a normal rainfall or irrigation event when water has infiltrated evenly - this will be near *field capacity.* If soil is sampled too dry or too wet, it may produce *lower* respiration.

2. **WEIGH SAMPLE INTO SOLVITA® JAR:** It is advised to weigh the sample or to use a standard volume scoop for all samples. **NEW: For the new Standard Solvita Jar (1 pt or 475 cc) use not more than 90 g (3 oz). For the old 8 oz (265 cc) jars use not more than 50 g (1.5 oz) moist soil.**

3. **NEW: VARIABLE SIZE TESTS**: The Solvita test is normally conducted in jars supplied in the kit which are the new Standard Solvita Jars (475 cc). The old version was 8 oz (265 cc) and both types fitted with air-tight rubber seals. 1-pt ball canning jars may also be used if they have rubber seals. The test may be performed with larger quantities of soil so long as the jar air size is proportional to the soil (see section 4. and NOTE on next page) since the test is recording CO_2 in headspace.

Test Period is
24 hours

Soil sieve fits into top
of standard 5-quart pail

Use a brush for cleaning
between sampling.

Results are read at 24hr using
either the DCR Field Unit (Green)
or the Multi-Mode DCR (Yellow)
using the ALT Mode key.

4. **VOLUME ADJUSTMENT (optional):** Different quantities of soil may be used in the test and still obtain equivalent Solvita results by simply adjusting the total volume accordingly, as shown below comparing Column (1) and Column (2 or 3).

(1) SOIL weight in grams	(2) US Jar Size	(3) Metric Jar Size
50	Solvita (8 oz)	265 cc
90	PINT **NEW:** Solvita Standard Jar	475 cc
180	QUART	925 cc (1 liter)
370	1/2 GAL	1900 cc (2 liter)

5. **START THE TEST:** The test starts when the Solvita CO_2 probe is inserted into the moist soil in the jar. Tear open the Solvita foil pouch and carefully remove the probe by the handle. *Avoid touching the gel surface, and don't allow soil to touch it.* Push the tip of the probe into the sample so the probe stands erect. Avoid jostling the jar. Screw the lid on tightly and record the start time. Keep the jar at a constant temperature (Interpretation in Table 1 is based on 70°F/20°C). See Table 2 for conversion factors.

6. **Use of Sieve inserted into a pail:** Standard soil sieves such as the one used in Soil Master Kit also fit into a common 5-quart pail obtained at most hardware stores. This provides a convenient means to handle preparation of soil.

7. **Cleaning the Wire Sieve:** Do not wash in between sieving, but use brush to clean. A steel wire brush is enclosed with the *Soil Master Kit* for easy cleaning.

8. **READ THE PROBE:** At 24 hours remove probe from the jar. Turn on the DCR Field Unit (Green Unit) or the Multi-Mode DCR (Yellow) in ALT Mode and insert probe gel side up. Press the read button to display color number (matching the visual color key) and the quantity of CO_2. For interpretation use the color number and see *Table 1.* An on-line calculator is available at *solvita.com/soil/basal-co2-guide*

NOTE: **Area and Size Considerations**: Solvita probes respond to concentration of CO_2 in the air volume (headspace + pore space). This is quantified based on the *Ideal Gas Law* (PV = nRt, assuming 1ATM at 20°C and ~20% water). If the air volume:solid mass ratio is held constant Solvita will lead to similar results regardless of the quantity of soil.

INTERPRETING CO_2 RESPIRATION

The following table suggests a general biological activity curve over the range expected for moist, cultivated soils measured at ambient temperature of 20-22°C (68-72°F). In-field, results may differ by a temperature factor shown in Table 2.

Table 1: Interpretation - Respiration in Test Jar at 20-22°C (68-72°F)

A	**Color 0 - 1.0 Blue-Gray**	**Color 1.0 - 2.5 Gray-Green**	**Color 2.5 - 3.5 Green**	**Color 3.5 - 4.0 Green-Yellow**	**Color 4.0 - 5.0 Yellow**
B	EXTREME LOW ACTIVITY Associated with very depleted soils	LOW ACTIVITY Limited bio-logical activ-ity with low carbon levels	MEDIUM-LOW ACTIVITY Medium active - accumulating carbon	IDEAL ACTIVITY Active microbes with carbon supply	HIGH ACTIVITY Very active biologically with very high carbon emissions
C	**ESTIMATED EMISSIONS (FLUX) OF CO_2-C as lb/acre**				
	1.5 - 2.0	**2 - 7**	**7 - 16**	**16 - 24**	**24 - 60**
	ESTIMATED EMISSIONS (FLUX) OF CO_2-C as kg/ha				
	1.7 - 2.3	**2.3 - 8**	**8 - 19**	**19 - 29**	**29 -70**
D	**INTERNATIONAL EMISSIONS (FLUX) OF CO_2 as grams / m^2 / day**				
	0.6 - 0.8	**0.8 - 2.9**	**2.9 - 7**	**7 - 11**	**11 - 26**

A: Color Reading of gel (this matches the official Solvita visual color key).

B: Suggested guideline to describe biological soil condition of cultivated soils.

C: Standard units to report respiration (see also Table 3, column D). Units are CO_2-C. Results depend on a variety of factors such as depth of sampling, soil temperature and field-moisture. Not to be confused with "CO2-Burst" from disturbed, dried and re-wetted soils

D: International Metric Units based on CO_2. For row C the units are CO_2-C (i.e as carbon). Use 3.7 to get to CO_2 (carbon dioxide) from CO_2-C or 0.273 to go from CO_2 to CO_2-C.

Table 2: Conversion from room temperature (70F/20C) to actual temperature as measured in the field at sampling*

Actual Temp:	40°F / 5°C	50°F / 10°C	60°F / 15°C	70°F / 20°C	80°F / 30°C
Divide by to get actual field result	**4**	**2**	**1.5**	**1**	**0.5**

Example of using Table 2: If soil temperature when sampling is 60°F/15°C, and you ran the test at standard 70°F/20°C, then take the CO_2-C lb/a result, divide by 1.5 then go to Table 1. See Solvita.com for the on-line calculator which makes continual adjustments for respiration at any given temperature. Conversely use the index to convert CO_2 rates performed at non-standard results back to standard 70°F/20°C data.(*https://solvita.com/soil/basal-co2-guide*)